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Development of Immersive Teaching Material using HMD and 3D Gesture Operation for Astronomy Education

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Abstract: The purpose of this study was to discuss usability of the immersive astronomical teaching material that enabled teachers to intervene in the virtual space. The pictures of starry sky and instructor's hand were presented in two conditions; the head mount display (HMD) condition and the PC monitor condition. 20 college students completed the questionnaire about asking to assess the ease of the 3D gesture-operations and switching of the view in tandem with user's bodily motions. The t-test reported that the HMD condition was significantly above the PC monitor condition. The results showed that there was the possibility that the switching the view corresponding to user's body motions allowed the students to more easily recognize orientation and direction, which was consistent with the findings of Kawasaki et al. (2010). Meanwhile, the results also indicated the possibility that the teacher's interventions in the virtual space promoted the understanding of the students.

Keywords: Virtual Reality, Astronomy Education, HMD, 3D gesture operation

1. Introduction

It is difficult for children and students to understand contents that require spatial awareness, and it is considered that it is one of factors that learner's ability of viewpoint movement is being growth stage (Tsuchida et al.1986). Learning based on observations of movement of stars and moon in elementary and junior high schools, it is effective outdoor observation that can provide accompanied by experience feelings. However, weather problems or time constraints, and considering geographical situations, practices in school education are practically difficult.

On the other hand, Virtual reality (VR) by using technology enable the simulated experiences in the virtual space to provide a celestial learning as an alternative field observation. Setozaki et al (2009), developed a VR teaching material for learning the mechanics of the phases of the moon, it showed that it is useful for improving the interest and level of understanding.

In astronomical field, there's a lot of individual variation to understand learning contents because it is related to spatial cognition. So it is considered that Head-mounted display (HMD) is useful as one of the ways to use VR materials for individual lesson for leaners who cannot understand spatial cognition easily. HMD can provide a higher immersion and prompt an observer to switch the view corresponding to user's body motions. Kawasaki et al (2010) developed a VR astronomical observation system using the HMD, reported that it is easy to recognize learner orientation and direction. Therefore, it can be expected as an interface that can solve the problem that Kusumoto et al (2010) described it is difficult to recognize orientation and direction by using a screen. However, while learners are building a VR environment by HMD, it is assumed that he is immersed in the VR environment alone, so it is difficult to be supported by teacher's intervention. If it is assumed the case of individual lessons for learners who are poor in an ability to understand the contents of the astronomical field, it is considered that the teacher's spatial interventions in the VR environment are effective.

Therefore, the purpose of this study was development of immersive astronomical teaching material that enabled teachers to intervene in the virtual space assuming the individual learning in

astronomical field. In addition, it was discussed usability of this teaching material by assessing from the point of view the ease of the 3D gesture-operations and the switching of the view in tandem with user's bodily motions.

2. Methodology

2.1 Development

Figure 1 shows an overview of the immersive astronomical teaching material. The immersive astronomical teaching material was developed through a Game Development Software (Unity5.0). The image of starry sky was used "Mitaka" (http://4d2u.nao.ac.jp/html/program/mitaka/) that astronomical configuration software of the National Astronomical Observatory of Japan.

The operation of the VR content was used a 3D gesture-equipment (Leap motion). Hand model in a virtual space by 3D gesture-equipment that is displayed, also can be operated at the time of the HMD. Furthermore, instructor can watch the virtual space by the PC monitor. It was intended to teach for the learner

2.2 Evaluation

The participants for evaluation in this teaching material were 20 college students. In the evaluation experiments compared "HMD group" with "PC monitor group", in order to evaluate the usefulness of the point of view movement with the learner of body motion. At the time of viewing-operation, in order to evaluate the teaching effect in a virtual environment, the author made a teaching and a description of the content. After the experiment, responses were obtained using a questionnaire.

As an evaluation of the usability of the viewpoint movement with the body motions, responses were obtained by four-point scale. Survey items were composed of "Direction (3 items)", "Motivation (3 items)" and "Interest (3 items)". Choices were "Strongly agree", "Agree", "Disagree", "Strongly disagree". The evaluation of the viewpoint movement with user's body motions was analyzed by t-test.

As the evaluation of teaching effect in the virtual environment, responses were obtained by four-point scale about the 3D gesture operation. Survey items were composed of questions about the "3D gesture- operation (5 items)". Choices were "Strongly agree", "Agree", "Disagree", "Strongly disagree". The evaluation of the 3D gesture-operation was analyzed by binomial test.

3. Results

20 college students completed the questionnaire asking to assess the ease of the 3D gesture-operations and switching of the view in tandem with user's bodily motions. The calculation of the t-test showed that survey items about "Direction (3 items)" were statistically significant. Therefore, the results showed that there was a possibility that the switching the view corresponding to user's body motions allowed the students to more easily recognize orientation and direction.

The calculation of the t-test showed that survey items about "Motivation (2 items)" were statistically significant. Therefore, the results showed that there was a possibility that the learner to work on the content diligently by HMD.

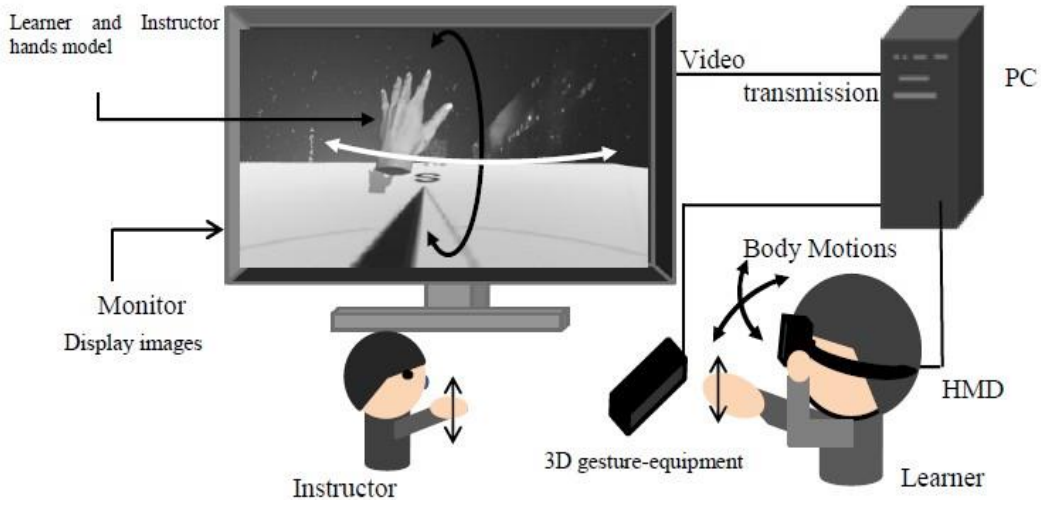

Figure 1. Overview of the Immersive Astronomical Teaching Material

Table 1. Result of evaluation about 3D gesture operation

Question items	Positive	Negative	p
Are you share information with instructor by displayed your hand model ?	19	1	*
Do you understand motion of celestial bodies ?	20	0	*
Is contact easy to understand by instructor's hand ?	20	0	*
Do you understand position of celestial bodies ?	19	1	*
Is 3D gesture-operation accurate ?	20	0	*

（＊＊：p＜.01）

The calculation of the t-test showed that survey items about "Interest (2 items)" were statistically significant. Therefore, the results showed that there was a possibility that HMD make learner to have interest in astronomical learning.

Result of evaluation about 3D gesture operation is shown in Table 1. The calculation of binomial test showed that survey items about "3D gesture-operation" were statistically significant. Therefore, it is inferred from the result that there was a possibility that 3D gesture-operation helps learner to understand direction and position of celestial bodies.

4. Conculusion

The purpose of this study was to discuss usability of the immersive astronomical teaching material that enabled teachers to intervene in the virtual space. The pictures of starry sky and teacher's hand were presented in two conditions； the head mount display (HMD) condition and the PC monitor condition. 20 college students completed the questionnaire asking to assess the ease of the 3D gesture-operations and switching of the view in tandem with user's bodily motions. The t-test reported that the HMD condition was significantly above the PC monitor condition. The results showed that there was a possibility that the switching the view corresponding to user's body motions allowed the students to more easily recognize orientation and direction, which was consistent with the findings of Kawasaki et al. (2010). And, the calculation of binomial test showed that "3D gesture-operation" were statistically significant. The results showed that there was a possibility that 3D gesture-operation helps learner to understand direction and position of celestial bodies. Meanwhile, the results also indicated the possibility that the teacher's interventions in the virtual space promoted the understanding of the students.

A further direction of this study will be to improve the astronomical teaching material and interface.

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